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Linguistic resources and cognitive aspects in alternative communication

Abstract

We present in this paper an alternative communication system (hereafter ACS) for handicapped persons. The problem consists in helping people to communicate in any situation with any kind of disability, including some kind of cognitive problems as well. Alternative communication primarily relies on an alternative access to the computer by means of various electronic devices (especially in the case of fully paralyzed people). But this also means the necessity of taking into account the communication situation together with the user characteristics.

The preliminary question when developing an alternative communication system concerns the specification of user need. Communicating does not only consists in producing a message or a text, eventually synthesized with a text-to-speech system. An ACS also needs to propose different kind of communications, including non-verbal ones.

Moreover, such systems have to consider some psychological aspects. In particular in the case of degenerative diseases, new device have to be introduced as new step in the degeneration are crossed. We propose an evolutionary system following users needs and capabilities, avoiding them the feeling of using a new device.

Technically, our system relies on a set of sophisticated and original linguistic resources (lexicon and grammars) allowing word access, word prediction and text composition. It also takes into account different kind of communications, from icons to texts via phonemes and morphemes (useful for example in a word completion process). Finally, it proposes the possibility of a multimodal control of the system. This system is currently under evaluation by several users in real-world situation.

1. Introduction

Various kind of handicaps lead to the incapacity, temporary or definitive, to produce written or intelligible oral messages. We are concerned herein with both physical and cognitive impairments, from general paralysis such as Amyotrophic Lateral Sclerosis pathologies (hereafter ALS), to some case of aphasia where the language production mechanisms are also severely damaged. Some tools have been already developed in order to provide assistance during message composition. For patients suffering from general paralysis, it consists for example in replacing the standard physical keyboard of the computer by a virtual keyboard controlled by eyelid winks. A cursor scans the virtual keyboard keys until the user selects the desired character by an eyelid click. The text is composed letter after letter and the resulting message can be eventually synthesized using a text-to-speech system. Despites the patent utility and the strong demand emanating from the Handicap community, the number of proposed Alternative Communication Systems (hereafter ACS) remains today insufficient. Moreover existing ACS fail to offer adequate solutions, in terms of efficiency, accessibility and adaptability, for a wide range of handicaps.

We constituted in 1999 a workgroup – the “Groupe Handicap”, designed to address the problems generally encountered when using alternative communication systems. Our group gathers linguists and computer scientists (Laboratoire Parole et Language, Aix-en-Provence and Laboratoire d’Informatique Fondamentale, Marseille), psychologists and ergonomists (Laboratoire de Psychologie Cognitive, Aix-en-Provence), physicians and physiotherapists (OthoRinhoLaryngology and Neurology departments) and staffs from Centre and Association for Handicapped Persons (ALS-France). This cross-disciplinary approach has been very fruitful and has led to very precise recommendations concerning the specification of a generic and efficient system devoted to assist the communication of users suffering from various handicaps.

A prototype version of such a system – “l’Assistant de Communication”, has been recently developed and is currently under evaluation in real world situation by users affected with different kind of disabilities. Our system proposes different modalities of accessibility which correspond to different levels of physical impairments. For example, it can be controlled by an eyelid movement sensor for patients affected with general paralysis, but it also allows to interact with mouse clicking and positioning in the usual way. A second attractive feature of our system is that the communication does not limit to written orthographic messages. Texts can be also composed using phonemes and morphemes (useful for orthographically challenged users for example), and non-verbal communication via an icons database is supplemented to patients who have lost or who have not developed their capabilities to produce verbal messages. Finally, our system integrates original methods and word prediction tools which considerably reduce the capture time of the composed messages.

We present in section 2 the conclusions on the specification of user needs driven from the 3 years reflection work of the “Groupe Handicap”. In section 3, the prototype version of our system is described, in emphasizing the advantages of our system compared to existing ACS. Finally, we discuss section 4 the perspectives of integrating a set of new functionalities and options in the future version of our system.

2. User Needs

As described in the introduction, many situations can lead to partial or total incapacity of communication. For some people, the problem is only functional, for some others, it is also cognitive, and in some cases, both can be combined. One of our goals is to be reusable according to the kind of handicap, as well as the communication situation. This means that the system has to take into account not only the capacity of the user to control the system, but also his/her cognitive abilities. Moreover, the observation of people using alternative communication devices shows that it is necessary to provide several different communication modalities. More precisely, we think that, as in non-assisted situations, a communication act is formed with several different modalities: written material (words, entire sentences), speech (sounds or isolated phonemes, words, sentences), images and gestures. In the same way, and according to the abilities of the user, an assisted communication act also would take advantage of these different modalities: a message can be composed, eventually in a mixed form, with words, sounds or images. When examining more closely the problem of people using assisted communication, it seems that the predominant modality depends on several factors: the user intention, its physical and cognitive abilities, but also the "hearer", the type of information to be send and even the situation. All these parameters contribute to specify a communication environment for each act.

Our system takes into account this general frame and proposes different kind of solutions answering to different problems: accessibility, lexical access (different technical and cognitive answers), localization, user profile, etc. We describe in the following more precisely three different aspects: accessibility, adaptation, and non-verbal communication.

2.1. Accessibility

The problem for persons suffering from muteness and paralysis mainly consists in elaborating an understandable message in an efficient way: communication has to be realized in a reasonable time by means of devices as natural as possible.

The first mechanism (at least the one proposed by most of assisted communication systems) consists in generating one or several sentences using an editing tool and eventually synthesizing them. We need for this high-quality synthesis systems together with tools improving efficiency of the editing phase. This last aspect remains a problem. If we need a system reducing the number of keystrokes, we also need a technique allowing to access rapidly to the chosen part of the keyboard. Practically, there is always a trade-off between these two constraints. One element of answer lies in the scrolling technique for accessing the keyboard and the control panel: in some cases, a key-by-key defilement is the best solution (menu, scans requiring special attention, etc.), in other cases, a dichotomy access offers the best access. Moreover, different techniques of word composition are proposed: character by character, dictionary access, multiple-criteria selection, etc. These techniques are presented in the next section. It is interesting to underline here the importance of proposing for each operation different solutions or different tools to the user. This characteristics is a pre-requisite for a good adaptation of the system.

Another element of answer, of deep importance as far as linguistic is concerned, consists in completing the device with prediction tools. The system in this case proposes the user different words (or icons in the case of non-verbal communication) filtered using some constraints (frequency, communication situation, user profile, linguistic properties, etc.). In this case again, different techniques can be implemented. Moreover, a high-level quality for the lexical resource is required. Our lexicon for French contains about 500.000 forms associated with morpho-syntactic, phonetic and frequency information. This constitutes one of the most important existing electronic resource for this language.

2.2. Adaptative communication

As explained before, it seems to us very important to follow the user needs under many aspects. One of them is the capacity of the system to be adaptable. This property concerns both the user and the situation in order to propose the best possible help. User adaptation first concerns the system ability to handle some user problems. Any kind of impairment can be associated with an assistance tool. Partial or total paralysis can be compensated with specific electronic devices in order to control a system or even a computer. For example, an optic fibre associated with an infra-red emitter can constitute an efficient sensor of eyelid winks. But several other kind of tools adapted to a specific impairment can be used. The first idea consists then in taking advantage of the possibility of using simultaneously different devices in order to control the system. Moreover, and this is an originality of our system, on top of making use of these different devices, it is necessary to accompany the evolution of the user. This means that, in case of degenerative pathologies, the system can propose more and more assistance tools according to the evolution of the disease. At the beginning, it can be used as a simple

editing system and, following the apparition of new impairments, new mechanisms can be introduced. This is interesting from the user point of view in particular because the system can be used all along the evolution. There is no need to acquire or learn new systems.

The second important aspect of adaptability concerns the communication situation. Indeed, the kind of communication, and then the kind of language to be produced, can be very different during a meal, a medical consultation or for writing a message. Each situation has then to be described not only from a linguistic point of view (lexical material, syntactic properties, semantic domain, etc.) but also from a psychological one (especially concerning ergonomics: use of synthesis, possibility of multi-modal communication, etc.) and even form a computational perspective (adaptation of the prediction technique to the communication situation). An assistance system, thanks to the specification of the situation, has then to make use of adequate resources, but also to propose a communication technique that can be different according to the situation. An elementary non-verbal communication is the indicated for very stereotyped situation (e.g. meals) whereas a more elaborated one, even mixing different modalities, would be necessary during more open situations.

2.3. Non-verbal communication

There exists different uses or non-verbal communication. Basically, it consists in associating an icon to a notion, a word or even a text. This approach can be complexified toward actual icon languages such as Bliss. We don't think such languages are adequate for the purpose of alternative communication. Indeed, the complexity of these codes rapidly reaches an abstraction level comparable with real languages. In such cases, the original benefit (flexible and robust communication) is lost. We then think preferable to limit the use of icons to very simple sub-languages, especially when icons are the only way to communicate. As soon as a more complex level of abstraction becomes possible, we propose to re-introduce progressively verbal language.

However, this doesn't mean that the use of icons cannot be structured. We then propose to describe an actual basic language taking into account a possible evolution of the user capabilities. A first approximation allows to distinguish different kinds of icons specifying a rudimentary syntax of the language. Different categories of icons can be distinguished according to the material with which they can be associated:

- *Sentences*: such icons corresponds to concepts or elaborated actions. Each icon constitute an entire message in itself. We find in this category messages such as "sitting on a chair", "cutting nails", "going to bed" or "washing the face".

- *Minimal predicates*: these icons usually corresponds to action verbs and must be associated with icons rpepresnting objects. We find here examples such as "lighting" "eating", etc. that can be associated with other icons in order to form messages such as "lighting+lamp", "eating+ham", "drinking+beer", etc.

- *Agents* : this category refers to a more abstract notion and corresponds to a more abstract level of complexity. We can combine these icons with minimal predicates in order to obtain sequences such as "I+eating" or "You+watch the TV".

- *Modalities*: This level, constitutes with modal verbs or some adverbs, makes it possible to introduce modalities in a sequence of icons. It can be combined with previous to obtain sequences as in "I+want+drinking" or "You+not+sleeping".

This typology of icons can serve as basis in order to re-introduce lexical material and eventually an elementary verbal language.

3. The "Communication Assistant "

Our assisted communication system, the "Communication Assistant ", is formed by three different set of components:

- A set of sensors for controlling the system
- A set of message editing and prediction tools
- A speech synthesis system

Les capteurs sont destinés à produire un signal binaire sur la base d'un mouvement quelconque pouvant être contrôlé par l'utilisateur. Dans la plupart des cas, au moins une modalité de contrôle reste à la disposition de l'utilisateur : le clignement de la paupière. Nous utilisons pour cela un système de fibre optique captant un signal infra-rouge mis au point par l'association ALS-France, partenaire de notre projet. Nous sommes actuellement en phase de développement de deux nouveaux dispositifs beaucoup plus légers, simples à mettre en oeuvre et de

plus moins onéreux que les existants. Nous travaillons de plus à l'intégration simultanée de plusieurs capteurs, formant ainsi un ensemble de modalités de contrôle.

Les outils d'aide à la composition de message forment le coeur de notre procédé. Ils sont formés par deux grandes sous-familles : les outils de composition à proprement parler et les outils de contrôle de l'environnement informatique. Ces derniers sont des fonctionnalités permettant d'accéder aux différents menus habituellement proposés dans les applications, ainsi que d'accéder aux contrôle du système d'exploitation lui-même. On se base pour cela sur l'utilisation de racourcis claviers permettant d'effectuer la plupart des opérations nécessaires au lancement des programmes et à leur utilisation. Nous mettons de plus au point une souris virtuelle, toujours contrôlée (dans le pire des cas) par un capteur binaire (type clignement de paupière) mais pouvant également tirer parti de mouvements plus évolués lorsqu'ils sont encore possible (par exemple contrôle d'un joystick).

Les outils de composition à proprement parler constitue en fait un ensemble de claviers virtuels mis à la disposition de l'utilisateur. Chacun de ces claviers correspond à une technique de composition particulière. Le clavier de base est une reproduction d'un clavier standard à l'. Le clavier de base est une reproduction d'un clavier standard à l'écran. Il contient donc toutes les touches habituellement utilisées, ce qui rend son utilisation tout à fait intuitive et naturelle. Un défilement paramétrable (par touche, par lignes/touches ou par lignes/blocs/touches) permet d'accéder au caractère visé. Une fonctionnalité de prédiction de mots peut être ajoutée à ce clavier, offrant ainsi la possibilité de composer un mot en réduisant le nombre de clics nécessaires à la sélection de chacune de ses lettres. D'autres claviers sont également proposés. Il tirent parti des possibilités de prédiction en réduisant le nombre de touches du clavier. Il est en effet possible, à condition de disposer d'un lexique très complet, de proposer l'utilisation de claviers ne comprenant qu'un sous-ensemble des lettres utilisées. La technique de prédiction s'appuie sur des informations de fréquence lexicale absolues (calculées sur des corpus) ainsi que sur les habitudes de l'utilisateur lui-même.

Le dernier composant du dispositif concerne les aspects de synhtèse de la parole. Cette fonctionnalité est utilisée de façon classique pour synthétiser les messages composés. Nous utilisons pour cela un système mis au point par un des partenaires de notre groupe. Ce dispositif nous permet de plus de proposer une fonctionnalité supplémentaire sous la forme d'un synthétiseur portable sur lequel les messages sont composés directement sous forme phonétique. Il s'agit d'une amélioration d'un système existant et peu utilisé essentiellement pour des problèmes ergonomiques.

Par ailleurs, « l'Assistant de communication » constitue un procédé global permettant de prendre en compte non seulement des besoins de communication, vocation première de ce type d'outil, mais offre également des possibilités d'utilisation en termes de rééducation. Il a été en effet développé en collaboration avec des orthophonistes et nous avons mené une réflexion sur l'utilisation des icônes en particulier sur deux aspect : proposition d'un accès structuré à une base d'icônes et réintroduction progressive du langage écrit. L'accès aux icônes est un problème important, on ne peut en effet pas se contenter, comme cela est habituellement fait, d'afficher un ensemble d'images. Nous proposons une structuration permettant de types les icônes à la fois du point de vue sémantique et syntaxique. Ces points nous permettent de nous diriger vers un outil non pas de véritable prédiction, mais en tous cas de filtrage de la base d'icônes permettant de faciliter leur accès. Cette caractéristique est liée au second point. Il est en effet possible d'une part d'associer du matériel lexical à chaque icône, mais également, compte tenu du fait que nous proposons une description syntactico-sémantique des icônes, de reformuler des structures simples. Mais à la différence des autres systèmes (expérimentaux) dans ce domaine, nous favorisons le langage écrit plutôt qu'un langage iconique complexe (type Bliss).

Il contient par ailleurs une utilisation particulière des outils de synthèse de la parole. Outre la synthèse classique d'un message, nous proposons également un accès au dictionnaire sous sa forme phonétisée, avec la possibilité de prononcer chaque mot (ce qui est utile dans le système de communication de base reposant sur les icônes).

D'une façon générale, notre procédé se situe entièrement du point de vue utilisateur. Concrètement, les méthodes d'accès proposées ne sont pas une simple simulation d'un clavier à l'écran, mais constituent des outils effectivement adaptés à une utilisation par défilement. Plus généralement, cette caractéristique ergonomique se retrouve également dans le choix des fonctionnalités, leur rôle et leur accessibilité. On propose ainsi une gestion de plusieurs capteurs permettant de contrôler le système. Il s'agit en quelque sorte d'une approche multimodale restreinte.

4. Discussion

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